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COMPARATIVE METHODS OF HANDLING PRODUCE FROM WAREHOUSE SLOTS TO HOLDING AREAS OF RETAIL STORES

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PREFACE

This study was conducted under contract with the Paul F. Shaffer Co., a management consulting firm located in Miami, Fla. The contract was administered by Daniel M. Steckler, industrial engineer, Food Distribution Research Laboratory, Agricultural Marketing Research Institute, Agricultural Research Service, Beltsville, Md.

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Applicants for all Department programs will be given consideration without regard to race, color, sex, creed or national origin.

CONTENTS

	<i>Page</i>
Summary	5
Introduction	6
Objective	7
Methodology	7
Warehouse labor and costs	8
The pallet system	8
Selection and loading for hand-stacked loads	9
The mobile cart system	9
The long - vs. the short-selection line	11
The warehouse labor costs and productivity compared	14
Effect of order size on selection productivity	15
Retail store produce-unloading labor costs	17
Pallet unloading	17
Unloading hand-stacked produce	18
Unloading with mobile carts	19
Unloading systems compared	20
Produce delivery costs	20
Pallet delivery	21
Hand-stack delivery	22
Mobile cart delivery	22
Delivery costs compared for pallets, hand stacking, and carts	22
Costs for equipment, dock ownership, and structural alterations	23
Total handling costs	24
Multistore produce deliveries vs. combining produce with other commodities	24
Recommendations	28
Appendix	29

COMPARATIVE METHODS OF HANDLING PRODUCE FROM WAREHOUSE SLOTS TO HOLDING AREAS OF RETAIL STORES

by

Paul F. Shaffer and Daniel M. Steckler¹

SUMMARY

The study of alternative systems of handling produce from warehouse selection of storage in the retail store showed that the pallet system was the least expensive, costing \$103.75 per 1,000 cases delivered, compared with \$113.40 for mobile cart shipment and \$140.71 when produce is hand stacked in the trailer. The study also showed that the availability of backhaul revenue (using the fleet equipment to transport freight on the return trip to the warehouse) further reduced the cost of pallet and hand-stack shipment in the cooperating firms. The total cost per 1,000 cases, with backhaul, was \$93.38 for pallets and \$130.95 for hand-stack delivery. There was no backhaul for cart shipments because the rigid carts (full and empty) used all available space in the trailer. Collapsible carts will free 75 percent of trailer space for backhaul freight, but the potential revenue should be adjusted for the added cost of the cart and the labor needed to erect and to collapse the cart.

Warehouse labor for selection was \$4.58 per 1,000 cases less for the pallet system than for the cart system. This was due to the greater capacity of the pallet and the less time required to select the case and to position it on the pallet.

Loading pallets on delivery trailers required \$1.98 less labor per 1,000 cases with pallets than with carts, and \$8.88 less than by hand stacking. Pallets were the least expensive because: (1) The pallet had a larger capacity; therefore, fewer trips into the trailers were necessary; (2) the selectors loaded the pallets, thereby eliminating parking on the dock; and (3) less time was needed to remove empty pallets (stripping) from

the trailer. Hand stacking was the most costly loading method because all cases had to be positioned manually in the trailer.

Retail labor costs for unloading full carts, moving them to storage, and loading empty carts back on the trailer were \$8.08 per 1,000 cases less than for pallets. This is based on half of the stores having truck bed-level docks and half using trailer elevators for carts and hydraulic lift platforms or a walkie-stacked lift fork for pallets. The least costly receiving method was carts over a dock (8.46 per 1,000 cases). Any potential advantage of hand-stack delivery (notably large trailer loads) was canceled by the high labor costs of unloading (\$37.80 per 1,000 cases).

Delivery costs were approximately the same for all produce-handling systems, although pallets had a slight advantage, \$49.43 per 1,000 cases, compared with \$51.48 for carts. Delivery costs were affected by trailer capacity, time to load and unload, and backhaul revenue. The backhaul revenue of the pallet firms studied reduced delivery costs to \$39.06 per 1,000 cases—\$12.42 per 1,000 cases less than cart delivery costs.

The cost of equipment, dock ownership, and structural alterations was \$9.12 per 1,000 cases more for carts than for the pallet system. This was due almost entirely to the cost of the mobile carts. The hand-stacking system was the least expensive (\$5.19 per 1,000 cases) because little equipment and modification were needed at the store level.

Studies were made of two types of selection systems: the long-selection line, where all produce items were slotted and where the selector's route covered all slotted areas, and the short selection line, where produce was removed from storage and temporarily staged in a selection line near the shipping dock. The cost of restocking and selection

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was \$12.40 per 1,000 cases higher for the short selection line. The higher cost was due to labor to set up the line and to return to storage the merchandise not selected.

The size of the produce order affected selection productivity. In one firm that had store orders that ranged from 5 to 200 cases, the labor cost of selection varied from \$31.05 per 1,000 cases for orders of 10 cases or less to \$16.40 for orders of over 75 cases. The greater time for the smaller orders was due to increased travel time to and from the dock and between case selection.

The question of whether to ship produce with the grocery order in a combination load or to serve several stores with a multistore (shuttle) run does not occur for metropolitan stores or for stores far from the warehouse and isolated from other stores. The

former should be shuttle runs and the latter combination loads. When out-of-town stores can be grouped to form logical delivery routes, then the key factors are total mileage per week to serve the stores and the frequency of delivery for produce and grocery for each store.

When stores were grouped in a triangular or in a straight line route, the combination load system was least expensive. Savings averaged 15 percent. Costs were identical for supplying a group of stores in a satellite city. As the ratio of produce to grocery deliveries increased, produce shuttle runs became the less expensive system. The firm should make certain that any delivery savings that result from combination loads are not at the expense of loss in produce quality when the trailer does not have proper temperature control for each commodity.

INTRODUCTION

The 1925-29 per capita consumption of fresh fruits and vegetables was 414 pounds annually. By 1972, the figure had dropped to 260 pounds.² Processed fruits and vegetables have been responsible for most of the decrease, plus competition from meat, soft drinks, and convenience foods. Produce-marketing executives are trying to reverse this downward trend, mainly through increasing nutrition awareness on the part of the consumer.

The need for better nutrition and improved diet is an important concern of Americans today. Since fresh fruits and vegetables are nutritious, produce executives believe that they have a good chance to increase their sales of fresh produce. Although educating the consumer on the nutritional value of fresh produce is helping, wholesalers and retailers must be able to hold down prices. Increased labor and transportation costs are making this difficult. The only way to hold down the cost in this period of inflation is through increased productivity. This means that the firms must receive a greater output for each input of a given factor of production, whether that factor be labor, equipment, or facility.

During the period of rapid growth of the food chains (1955-70), there was less concern for operational efficiency than for increasing volume. New stores and the greater volume for existing outlets would usually compensate for any poor decisions relating to equipment, labor methods, or facilities.

The emphasis on continually increasing volume also tended to restrict efforts to employ a total systems approach to solving problems in food distribution.

Today, the situation has been drastically altered. Many storage areas are over stores; hence, new volume is more difficult to achieve. Discounting and expanding merchandising lines have failed to generate the volume required to offset continually escalating costs of labor, equipment, and facilities. Rising costs of doing business create pressure to increase prices; yet, there is another pressure to hold the line on food prices because they are a constant and substantial part of the household budget. This is demonstrated by the experience of the food industry during Price Control and especially during Phase III. The combination of rising costs and the pressure on the retail food industry to hold the line on prices resulted in a profit picture that ranked as one of the lowest in the economy.

Each distribution-center manager studies his operation and installs improved handling techniques for produce distribution. Some techniques adopted are: (1) The 48-inch by 40-inch hardwood pallet as the standard of the industry, (2) motorized tuggers and pallet jacks for produce selection, (3) trailers with hydraulic trailer gates or recessed elevators, and (4) hydraulic unloading lift platforms at the store.

The produce-distribution cycle consists of selection, stock replenishment, trailer loading, delivery, and unloading at the store. The best total system for the particular firm should be selected because of the frequency that produce is delivered to the store.

²Co-op and Voluntaries, v. 3, No. 3, p. 57.

Three parts of the total system are keys to productivity: The platform for shipment, the layout of the selection line, and the receiving facility at the store.

The most typical delivery platform is the 48-inch by 40-inch warehouse pallet. This platform is used for storage of product; therefore, it is available for shipment of product to the store. It has an advantage in that full pallets of high-volume items can be selected and loaded, thereby eliminating the handling of individual cases. It is a unified system; cases are selected on the pallet and remain there until removed in the store for processing or display. To qualify as a unified handling system, it must be capable of unloading the pallets at the store. This can be accomplished by a trailer bed-level dock, a lift platform, or a hydraulic lift on the trailer.

The four-wheel mobile cart has the following dimensions: 27 or 29 inches wide, 57 inches long, and 72 inches high. Carts are rigid or collapsible and with a shelf or without one. The carts in the firm studied were rigid and had a shelf. Carts are also a unified system, assuming the store has a dock or a lift device to lower them to the ground.

A rapidly disappearing system is the shipment of cases hand stacked (or dead pile) on the trailer floor. The cases can be selected on a four-wheel selection truck (float) or on a pallet. The cases are then loaded by hand and unloaded at the store by such methods as conveyor, carrying by hand, two-wheel hand-trucks, and semilive skids. Hand stacking is not a unified system since the cases must be handled at least four times. Nevertheless, it does have an advantage in fully utilizing space in the delivery vehicle.

The layout of the produce selection area is a factor in selection productivity. The "short-selection line" is a system where produce is placed (or staged) in an area near the dock. One or more slots are reserved for each item, and as that item becomes depleted, more product is brought from storage. The selector travels once around the short line. The system has the advantage of reduced selector travel, but additional product transport occurs in traveling to storage and back again. The "long-selection line" concept is similar to the grocery warehouse selection system—items are selected from assigned storage slots, either racks or floor stacks.

Objective

The objective of this study is to determine and compare the costs of labor and equipment for selecting, loading, delivering, and unloading produce with alternative methods and equipment, and to

determine the least expensive total produce distribution system from warehouse selection to retail store storage. A secondary objective is to provide the distribution center manager with research data, so that by using his labor, equipment, and delivery costs, he can construct the best overall produce-handling system for his firm.

Methodology

To accomplish the objectives of this study, six warehouses were selected for detailed analysis of produce selection and loading.³ Four warehouses had long-selection lines, with three firms selecting and shipping on pallets and one firm on carts. Two firms had short-selection lines, with one firm shipping on pallets and the other by hand stacking. Produce was loaded on delivery vehicles by one of three methods:

1. Hand stacking the produce into the trailer from a four-wheel selector truck or a 48- by 40-inch pallet.
2. Positioning a loaded pallet into the trailer.
3. Positioning a loaded mobile cart into the trailer.

Produce-unloading studies were taken in 40 stores with a variety of equipment and methods. The principal ones were:

1. Unloading carts across a truck bed-level dock.
2. Unloading pallets across a truck bed-level dock.
3. Unloading carts using a built-in elevator in the trailer
4. Unloading pallets using a hydraulic lift platform or a walkie-stacker lift fork.
5. Hand-stacking produce; unloading without a dock; and using conveyors, two-wheel hand-trucks, and semilive skids.

The costs of delivery, labor, and equipment were obtained from the cooperating firms' financial records and were averaged to eliminate differences that were due to geographic locations. Production standards were developed for all warehouses and retail store operations. In all instances except forklift operators (5 percent), a 15-percent allowance was included for the operators' personal time and fatigue.

³The produce warehouses of the cooperating firms are shown in figure 4 and in appendix figures 11 through 14.

Each job was divided into work elements that were measured by repetitive stopwatch readings. The time required to perform the elements was adjusted to reflect the speed at which the operator worked.

WAREHOUSE LABOR AND COSTS

The study of alternative methods and equipment for the produce warehouse outbound operation included the labor for: (1) Forklift servicing the racks when performed as a part of the selection operation, (2) selecting cases from storage, (3) loading produce in trailers, and (4) removing (stripping) from the trailer empty pallets, carts, or other salvageable containers. Forklift servicing (restocking) was included because this is an essential function of the short-selection line. The short line's effectiveness is related to the extent that it can reduce travel during order selection and travel to the dock and return.

Therefore, the line must be set up before selection and restocked during selection, and excess product must be returned to storage after selection. Since restocking is included for the short line, it must also be included for the long line. Product on pallets must either be lowered from upper storage rack positions or else moved toward the aisle if all products are on the floor level. The labor to verify the accuracy of the merchandise selected with the picking list is typically a part of the selection operation. This occurred only in some warehouses studied, and when it occurred, the extent of the checking varied considerably. Therefore, checking was omitted from all studies. Several adjustments were required to place all systems studied on the same basis:

1. Watermelons were eliminated because percent of total pieces selected and the methods of handling varied in the firms studied.
2. The layout of the warehouses with long-selection lines varied considerably, and this affected travel to the dock and return. Therefore, an average travel time was used to eliminate the difference in layout.
3. Differences occurred in the pallet selection firms in the percent of product that was hand selected and pallet selected. An average of 85 percent handpicked was used by all pallet selection firms.
4. All orders with fewer than 50 cases were eliminated to compare the firms that served different size stores.

Systems of handling produce were studied, not firms. For this reason, average productivity and costs were used for firms that had a common handling system.

5. Stock replenishment labor was averaged for the firms that had long-selection lines.

The platform used in selection largely determines the handling procedures for the balance of the produce-distribution cycle. Pallets and carts are unified systems, with product remaining on the pallet or cart until it is removed for processing in the store. Loads shipped hand stacked in the trailer were selected on pallets or four-wheel selector trucks, but these were unloaded at the store by various methods.

The Pallet System

Pallet selection and loading were studied in three firms. All firms used electric pallet jacks to move the pallet, and all firms used pallet racking for most produce items. The selectors were also responsible for loading; that is, moving the loaded pallets into the trailer.

Order Selection

When produce is selected on pallets (fig. 1), the operation begins when the selector obtains the selection invoice and ends when he reverses the direction of his pallet jack to enter the trailer. In two firms, it included wrapping one or more bands of tape around the loaded pallet to increase the stability of the load. The pallets were not taped in firm B because



Figure 1. —Selecting produce on a pallet with a pallet jack.

the cases were hand stacked in the trailer. In some instances, pallets were double stacked, either during selection or loading. The bottom one would be a pallet container or a pallet uniformly loaded with one item so that it could support the weight of a second pallet. Productivity was markedly similar in the three long-selection-line firms, varying only from 197 to 213 cases selected per man-hour. At an estimated wage rate of \$4.50 per hour, the cost per 1,000 cases was \$24.98 in firm D, \$26.18 in firm B, and \$24.45 in firm G (table 1).

Trailer Loading

All firms used dock foremen or expeditors to direct the loading activities. Their labor was excluded from the loading studies because their duties varied by firm, and they were not typically involved in physically loading the trailers. The pallet-loading operation consisted of guiding the single- or double-stacked pallets into the trailer, and when necessary, reorganizing to insure that the load would be stable.

The standard time for trailer loading with pallets varied from 34 to 39 minutes per 1,000 cases. In the three firms, average productivity was 1,622 cases per hour at a cost of \$2.77 per 1,000 cases. The average pallet-loaded, 40-foot trailer held 787 cases when fully loaded, but without any hand-stack top loading of the pallet loads.

Selection and Loading for Hand-Stacked Loads

Most firms try to avoid hand-stacking produce because the system involves a minimum of four handlings: (1) Lift onto the selection platform, (2) transport to the trailer floor, (3) carry to trailer door or place on conveyor, and (4) place on ground or some platform for transport into the store. Generally, hand stacking is restricted to stores that are a great distance from the warehouse where utilization of trailer cube is important and to loads that are delivered to many small stores from one trailer.

Order Selection

Two platforms were used to select the hand-stacked loads (fig. 2); there were four-wheel selector trucks (floats), which were either pulled by hand or with a tugger, and pallets that had been placed on electric pallet jacks. In firm B, the selectors used a long-nose pallet jack that held two pallets, or floats, pulled by a tugger. In firm A, all produce was selected

on a four-wheel selector truck that was pulled manually. Productivity in selection was identical in firm B whether pallet jack or four-wheel selector trucks were used. Selection in firm A on four-wheel selector trucks using the short-line system, and without stock replenishment, was the most costly



Figure 2.—Selecting produce by hand on a four-wheel selector truck.

system studied—361 man-minutes per 1,000 cases, compared with an average of 251 man-minutes for pallet selection (long line), and 307 man-minutes per 1,000 cases for cart selection (long line) (table 1).

Trailer Loading

In the cooperating firms, the selectors parked the loaded selector trucks on the shipping dock, and a loader took over the loading. In two firms that stacked by hand, several produce orders were combined on the trailer, and nets were used to separate the store orders. The standard time for hand-stacked loading varied from 147 minutes to 166 minutes per 1,000 cases and averaged 155 minutes. At the assumed wage rate of \$4.50 per hour, the average cost was \$11.65 per 1,000 cases (table 2). Productivity was the same in firm B for loading from pallets and 4-wheel selector trucks and averaged 387 cases per man-hour in the three firms.

The Mobile Cart System

The mobile carts used in firm E were rigid, as opposed to the collapsible carts used by some firms, and their shelves were approximately 66 inches high. Some carts were equipped with racks for loading watermelons. The 29-inch wide cart was too narrow

Table 1.--Cost and productivity per 1,000 cases for alternative systems of selecting produce¹

Selection activity	Pallet				Hand stacking		Carts
	Long-selection line			Short line	Long line	Short line	Long line
	Firms						
	D	B	G	F	B	A	E
	Man-minutes	Man-minutes	Man-minutes	Man-minutes	Man-minutes	Man-minutes	Man-minutes
Select case:							
Hand select ²	102	101	81	80	104	107	127
Pallet select ²	6	6	2	4	14	--	--
Check picking list.....	25	2	17	19	2	20	25
Travel between picks.....	44	55	56	54	59	73	50
Travel/platform elements:							
Obtain platform and load.....	10	25	11	11	19	42	24
To selection area ³	9	15	12	15	10	26	15
Return to dock ³	15	23	19	24	16	41	24
Write on load.....	5	--	--	--	3	--	--
Tape to secure load.....	4	--	15	--	--	--	--
Irregular elements:							
Order related.....	4	15	13	13	15	5	15
Case related.....	8	4	--	7	3	28	8
Delays ⁴	19	19	19	19	19	19	19
Total elemental time.....	251	265	245	246	264	361	307
15% personal & fatigue.....	38	40	37	37	40	54	46
Total standard time.....	289	305	282	283	304	415	353
Cost per 1,000 cases ⁵	\$21.68	\$22.88	\$21.15	\$21.22	\$22.80	\$31.12	\$26.48
Stock replenishment.....	\$3.30	\$3.30	\$3.30	\$16.89	\$3.68	\$3.30	\$3.30
Total cost per 1,000 cases.....	\$24.98	\$26.18	\$24.45	\$37.61	\$26.48	\$34.42	\$29.78
Selection productivity in cases per man-hours ⁹	208	197	213	212	197	145	170

¹All store orders with less than 50 cases were eliminated from the comparison of selection systems. In addition, all studies were adjusted as follows:

- Watermelons were eliminated from all studies.
- The same ratio of manual select (85%) to full or partly full pallet selection (15%) was used in all studies, except for firms A and E, which used floats and mobile carts, respectively.
- The same time to move to the selection area and to return to the dock was used in all firms in order to adjust for differences in produce warehouse layout. The average time for the round trip was divided by the average number of cases per trip as recorded in each firm.
- Delays were averaged for all studies. The delays in the aisle, at the dock, or while waiting for a forklift drop were due to the layout and the operating practices, and not to the selection system used.

²Hand select - 85% and pallet select - 15%.

³The average time per round trip in all studies was 1.096 man-minutes.

⁴The average delay was 0.019 man-minute per case.

⁵Based on an average wage rate of \$4.50 per hour.

⁶Based on an average labor requirement of 1.46 man-minutes per pallet of 20 cases (0.073 man-minute per case) for an estimated 60% of the cases selected - the balance of the produce would be on the floor level and not require restocking. 0.073 x 0.60 x 1,000=44 man-minutes per 1,000 cases.

⁷See table 3 for additional details.

⁸This is the labor by the forklift operator to restock the short line and to make drops in the other selection/storage area - 49 man-minutes per 1,000 cases.

⁹Calculated as follows: 60 minutes ÷ man-minutes per 1,000 cases x 1,000.

for the pallet loading of produce; hence, all cases were placed on the cart manually.

Order Selection

Order selection (fig. 3) consisted of obtaining store orders at the dock, hooking one or more carts to an electric tugger, traveling to the selection area, selecting cases manually, and returning to the dock where the loaded carts were parked. On the average, the loaded carts held 28 cases. Productivity for produce selection with carts was at the rate of 170 cases per hour and at a cost of \$29.78 per 1,000 cases (table 1).

Trailer Loading

Firm E was typical for the loading procedure, in that the selectors parked the loaded carts on the shipping dock behind the assigned door, and then the loader moved the carts into the trailer. The loader would generally wait until several carts had accumulated and then load with the objective of properly balancing the weight in the trailer. The loader often had to wait for all the carts from one store before he could load the next store's produce.

The pattern used to load carts consisted of alternate groups of three carts, with each group positioned

so that one cart was parallel with the side of the trailer, and two carts were perpendicular to the side of the first cart. The typical full load on a 40-foot trailer was 23 carts, with only two carts on the elevator at the rear of the trailer. When the carts were loaded, a load-locking bar was installed to prevent their movement. The reason that the cart system had the highest average time to prepare to load and to complete loading was due to this installation of the load-locking bar. Typically, the loader would be removing empty carts two at a time from one trailer while he was loading a nearby trailer.

The standard time for loading carts on trailers (including stripping) was 63 man-minutes per 1,000 cases. This provided a productivity of 952 cases per hour at a cost of \$4.75 per 1,000 cases (table 2).

The Long - Vs. The Short-Selection Line

In the past, when a firm was able to purchase anticipated produce shipments daily, usually at a local terminal, and ship all receipts to the store on the same day, a good material-handling procedure was to place all inbound produce in a compact selection line in the shipping area. This is the true short-selection line. The only equipment required was a pallet jack

Table 2.—Labor productivity and cost per 1,000 cases for loading produce into delivery trailers by three systems of handling¹

Operational element	System					
	Pallet		Hand stacking		Cart	
	Time	Cost	Time	Cost	Time	Cost
	Man-minutes	Dollars	Man-minutes	Dollars	Man-minutes	Dollars
Strip inbound trailers of empty pallets and salvage	4	0.30	--	--	17	1.28
Move loaded pallet into trailer and return to dock	21	1.58	48	3.60	31	2.32
Hand stack or top off load	4	.30	85	6.38	1	.08
Prepare to load and complete loading	2	.15	2	.15	6	.45
Miscellaneous loading	1	.08	--	--	--	--
Total (elemental time and cost)	32	2.41	135	10.13	55	4.13
15-percent personal and fatigue	5	.36	20	1.52	8	.62
Total (standard time and cost)	37	2.77	155	11.65	63	4.75
Productivity in cases loaded per man-hour ²	1,622		387		952	

¹Labor based on an average wage rate of \$4.50 per hour or \$0.075 per minute.

²Calculated as follows: 60 minutes ÷ total standard man-minutes per 1,000 cases x 1,000.



Figure 3. —Selecting produce with mobile carts and an electric tugger.

and a two-wheel handtruck or four-wheel selector trucks. When firms began to buy in larger quantities and the variety of items and produce volume increased, all incoming produce could not be placed in the selection area. Frequently, the selection area did not have adequate refrigeration and humidity, so there was loss in product quality. The modern produce warehouse has high, level storage on racks and proper refrigeration with assigned slots for each produce item and a fixed selection route. This is the long-selection line, where the selector passes all slots while assembling the order.

To determine whether the longer travel of the selector on the long line compensates for the added product moving to stage the short line, two firms with short lines were studied. Firm A had a partial short line where 38 percent of the produce (high-volume items) was staged. Selectors assembled the balance from assigned storage slots. All items in firm F, with the exception of palletized melons, were staged in the short line. Before the selection period, a forklift operator would move merchandise from storage to the short line. During selection, one or two forklift operators constantly patrolled the line and restocked empty slots. After selection, a forklift operator moved the remaining product to storage. A few items, such as potatoes and onions, remained on the short line. The cost of moving produce to the short-selection line and return in firm F was \$16.72 per 1,000 cases selected (table 3). The cost of restocking was almost equal to the cost of selection.

The short-selection line did not materially reduce selection time in firm F—in fact, selection was at the same rate as in the three firms that used pallets with long-selection lines (table 1). The high cost of restocking and the fact that selection productivity was no greater than on the long line is explained by the layout of firm F in figure 4. When space is provided for full pallet storage for approximately 150 items on the short line, the distance traveled by the selector is almost equal to that traveled in a long-selection line. The distance from the short line to permanent storage explains part of the high cost of restocking. The best comparison of the short line of firm F is with pallet firms D, B, and G, since the four firms used electric pallet jacks in selection. The cost of the combined selection and restocking per 1,000 cases was \$37.61 for firm F, compared with an average cost of \$25.20 for firms D, B, and G (table 1).

The short-selection line in firm A was not a true short line because only 38 percent of the items were staged in the short line. The high cost of selection and restocking in firm A (\$34.42 per 1,000 cases) was due in large part to the extensive travel requirements for the selectors to cover all storage areas as well as the short line. This time for “travel between picks” and “travel to and from the dock” was 73 percent higher than in the three firms that used pallets with long-selection lines. Firm A, with only a partial short-selection line, had the second highest cost (\$34.42 per 1,000 cases) in the study.

Table 3.—Labor required to move produce to a short-selection line and return—firm F

Day	Cases selected	Total cases moved to selection line	Time to move product to line	Cases returned to storage	Time to return cases to storage	Total time to move product to storage and return ³	Total cost ¹	Total cost of restocking per 1,000 cases selected ²	Time per 1,000 cases selected to move product to storage and return ³
	<i>Number</i>	<i>Number</i>	<i>Man-hours</i>	<i>Number</i>	<i>Man-hours</i>	<i>Man-hours</i>	<i>Dollars</i>	<i>Dollars</i>	<i>Man-hours</i>
Sunday	5,040	6,705	15.87	1,212	1.53	17.40	78.30	15.54	3.45
Wednesday	2,835	4,270	9.97	1,030	1.30	11.27	50.72	17.89	3.98
Average	3,938	5,488	12.92	1,121	1.42	14.34	64.51	16.72	3.72

¹Total man-hours to move product to storage and return x average wage rate of \$4.50.

²Total cost ÷ case selected x 1,000.

³Total time to move product to storage and return ÷ case selected x 1,000.

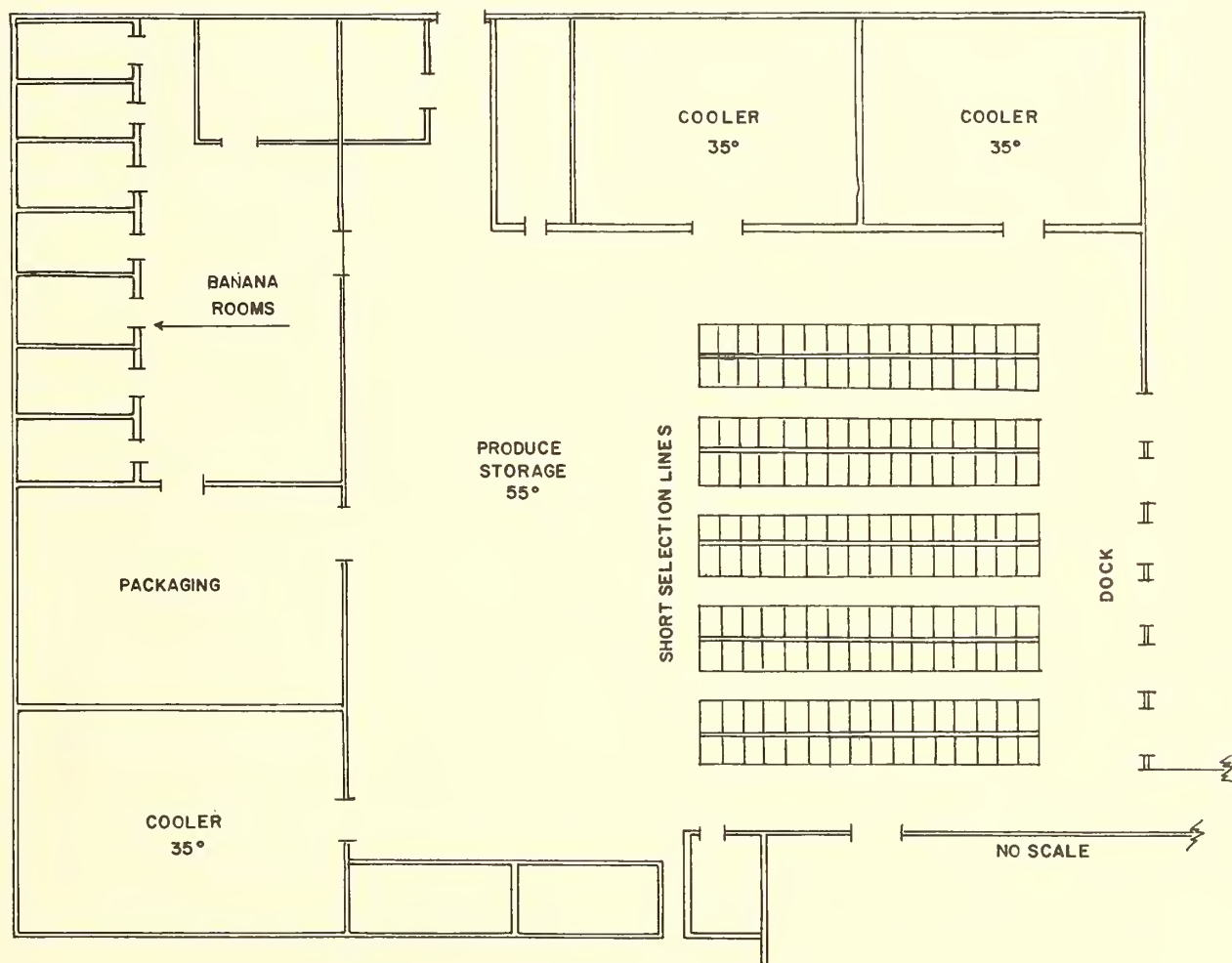


Figure 4.—Produce warehouse with short-selection line—firm F (temperatures in °F).

The Warehouse Labor Costs and Productivity Compared

The comparison of the pallet, cart, and hand-stacking systems of handling product are henceforth limited to warehouses with a long-selection line. The studies at firm F, with a complete short line, and at firm A, with a partial short line, showed that selection and restocking required less labor on long-selection lines. The least costly selection and restocking occurred when pallets were used. The average cost per 1,000 cases in firms B, D, and G (pallet system) was \$25.20, compared with \$29.78 for a cart system and \$26.48 for stacking by hand.

Pallets are the least expensive system for loading trailers (including the removal of empty containers and salvageable containers). Productivity was 1,622 cases per man-hour for pallets, compared with 952 for carts and 387 for stacking by hand (table 2).

For loading at the warehouse, the least expensive system is selection and shipment on pallets (table 4). Productivity in cases per man-hour was: pallets, 161; carts, 130; and hand stacking, 119. The cost per 1,000 cases was \$27.97 for pallets and \$34.53 for carts. The cost of a hand-stacking system (37.83) would be higher if a short-selection system had been included in the total cost. The pallet system required less time than the cart system because:

1. The loaded pallet had a greater capacity than carts; therefore, travel trips were reduced.
2. High-volume items like lettuce can be selected by the full or partly full pallet, while the cart system requires the selector to select each case and place it on the cart.
3. Detailed time studies revealed that more time was required to select the case and place it on the cart.
4. Removing empty carts required more time from a trailer than from pallets.

The shelf on the cart possibly both reduced its overall carrying capacity and also increased the amount of time to position the case on the cart. Hand stacking was the most costly system because of the extra case handling in loading. Selection labor can be reduced by increasing the percent of items that are selected and/or loaded by pallet. For example, items such as bagged potatoes and watermelons can be shipped in pallet-sized containers. These items and pallet-sized quantities of such items as bananas and lettuce can be assigned to a forklift operator, who then selects and loads the pallets, which are usually stacked double in the trailer.

Table 4.—Summary of warehouse labor requirements and cost per 1,000 cases for order selecting, restocking, and trailer loading for the pallet, cart, and hand-stacking systems¹

Operating function	System					
	Pallet		Hand stacking		Cart	
	Time	Cost	Time	Cost	Time	Cost
	Man-hours	Dollars	Man-hours	Dollars	Man-hours	Dollars
Order selection	24.87	21.90	35.08	22.88	5.88	26.48
Restocking ²	.73	3.30	.73	3.30	.73	3.30
Trailer loading ³	.62	2.77	2.58	11.65	1.05	4.75
Total (standard time and cost)	6.22	27.97	8.39	37.83	7.66	34.53
Productivity in cases per man-hour ⁶	161	--	119	--	130	--

¹Based on an average wage rate of \$4.50 per hour.

²From table 1, firms D, B, and G.

³From table 1, firm B (pallet and float).

⁴From table 1, all firms except B and F.

⁵From table 2.

⁶Calculated by dividing 1,000 cases by total man-hours.

EFFECT OF ORDER SIZE ON SELECTION PRODUCTIVITY

Store orders with less than 50 cases of produce were removed from the comparison of produce-handling systems because there was sufficient evidence that order size is a factor in selector productivity. This is shown in figures 5 and 6, where order size is related to total selection time expressed in minutes per case.⁴ Selection labor per case increases sharply in each firm when the order is less than 30 pieces. This is because the time is fixed to obtain a platform, to travel to the selection area, and to return to the dock. As long as the selector pulls a full load to the dock, selection productivity is relatively the same for all other sizes, except when a high percentage of the items are full or partly full pallet selections.

⁴Information on small order sizes can be found in Marketing Research Report No. 665, "Three Methods of Loading Out Produce in Warehouses," USDA, ARS Information, Hyattsville, Md. 20781.

The other factor that results in reduced productivity for smaller orders is the travel (time and frequency) between merchandise selections. Larger orders have more multiple case selections per line item, so travel frequency is reduced. As the order size increases, the time per case selected to travel between selections increases. This is shown in the chart (fig. 7) for firm E. The labor cost per 1,000 cases selected in firm F varied from \$31.05 for orders with less than 10 cases to \$16.40 for orders with over 75 cases:

Number of cases per order	Cost (\$) per 1,000 cases
0 to 10	31.05
11 to 20	26.50
21 to 30	25.30
31 to 40	22.40
41 to 50	19.50
51 to 75	17.35
Over 75	16.40

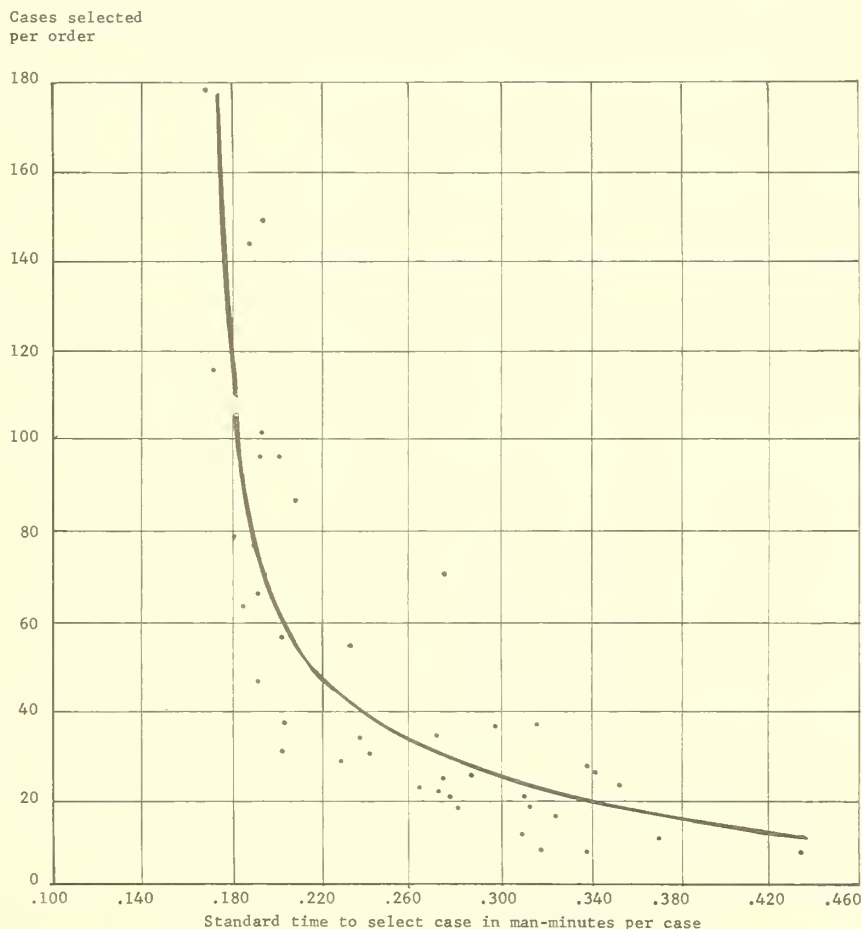


Figure 5.—Relationship of order size to produce order selection time in man-minutes per case—firm F.

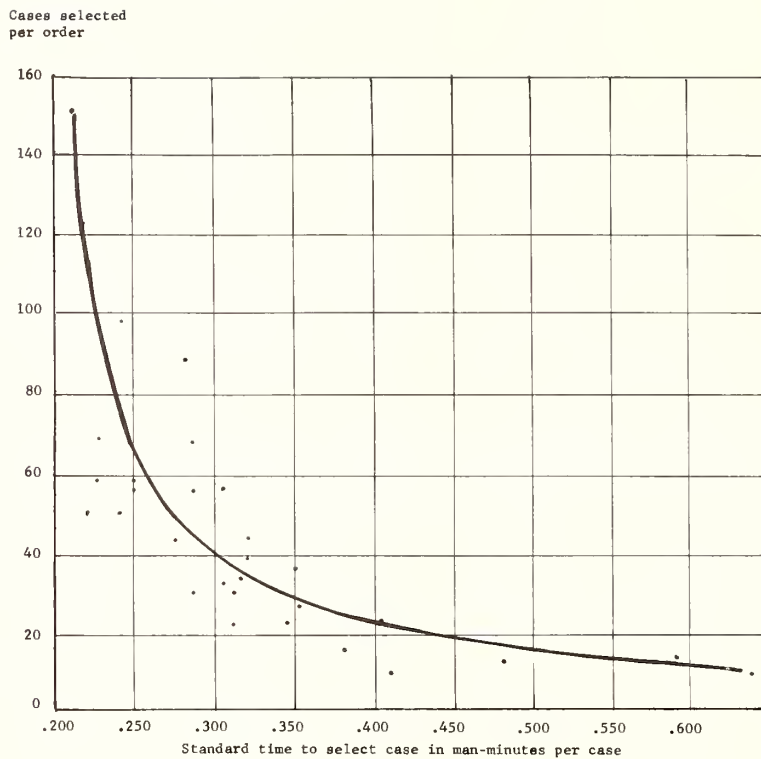


Figure 6. Relationship of order size to produce order selection time in man-minutes per case—firm B.

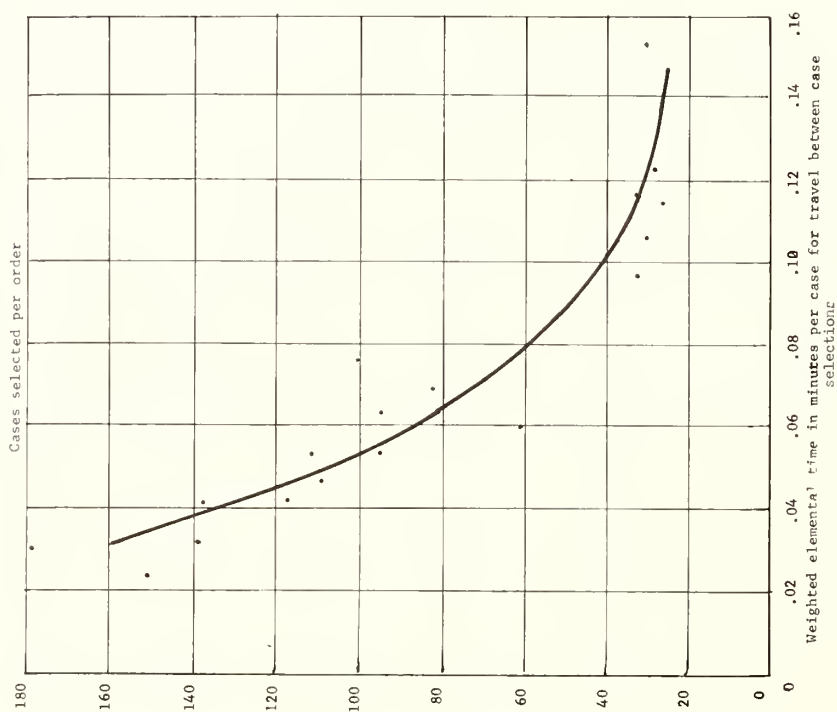


Figure 7. Relationship between size of produce order and the weighted elemental time per case to travel between case selections in the produce warehouse—firm E.

RETAIL STORE PRODUCE-UNLOADING LABOR COSTS

A delivery platform (pallet or mobile cart) can be standardized at the warehouse to obtain labor savings in selection and loading, but all too often the system breaks down when the trailer arrives at the store. This was evident in the methods of produce unloading observed in the 40 stores included in this study in which each store used a different operation. The best insurance that a standardized unloading method would be used was the cart system. In it, there were only two options: unload over a truck bed-level dock or unload over a lift platform incorporated in the trailer. The greatest variation in unloading methods occurred where the produce cases were stacked by hand in the trailer.

The type of delivery platform (pallet, cart, or none) is but one of the many factors that combine to affect unloading-labor costs. The unloading facilities and equipment at the store are key factors in productivity. A truck bed-level dock is the mainstay in planning efficient unloading. A level parking area with good access, large receiving doors with no obstructions for rolling equipment, and produce storage near the trailer parking area are also determinants in unloading efficiency.

The stores at the first stop had an advantage because of the reduced travel of the trailer, less maneuvering of the full pallets, and less likelihood of cases toppling on the floor of the trailer. Store layout was a consideration in receiving-area productivity. The further the produce storage area was from the trailer, the greater the chance for increased travel and for bottlenecks to develop in aisle. A final factor that affected total receiving productivity was whether salvage was returned and, if so, how much. The drivers were reluctant to load salvage on their first stop because they had to work around it on subsequent stops.

The time to perform such operations as "part trailer," "open trailer," "close trailer," and "check store bills" is not affected by the size of the order; therefore, the unloading time per case for a small order is higher than for a large order. To eliminate the effect of differences in order sizes and to compare systems of unloading on an equal basis, production standards were developed for the average size order, which was 200 cases for the cart and pallet loads. The time to "open store" and "close store" was more related to whether someone was available at the store than to the system of unloading. The order was checked in only 16 stores, and the time to check ranged from 1 to 20 minutes. The inclusion of these

elements would tend to distort the evaluation of unloading systems; therefore, they were omitted.

Generally, the produce was parked or stacked in the main storage area of the produce backroom or in a locked receiving room. In those stores where the order was dropped on the ground at the receiving door, an adjustment was made to move the produce into the store. Retail store employees were rarely used in unloading, primarily because deliveries were made during the night. When they assisted in the unloading, the store employees were considered assistants to the driver, and their time was charged to receiving.

Pallet Unloading

This system applies to those stores where the load was both delivered and unloaded on pallets (fig. 8). The driver worked alone, except for occasional store employee assistance with heavy pallets. The pallets were either parked in the produce backroom or in the cooler. When the unloading was complete, empty pallets and salvage material were loaded on the trailer. Two methods of receiving pallets were studied: the truck bed-level dock and the hydraulic-lift platform.

The truck bed-level dock will reduce unloading labor by 49 percent when compared with the



Figure 8.—Unloading produce on pallets.

Table 5.—Labor productivity and cost per 1,000 cases for unloading produce at the retail store¹

Activity	Pallets				Carts			
	Dock unload		Lift platform		Dock unload		Trailer lift	
	Time	Cost	Time	Cost	Time	Cost	Time	Cost
	Man-hours	Dollars	Man-hours	Dollars	Man-hours	Dollars	Man-hours	Dollars
Prepare to unload and close up	0.55	2.64	0.60	2.88	0.52	2.48	0.62	2.96
Unload full pallets and park in backroom	1.32	6.32	2.92	14.00	.58	2.80	1.10	5.28
Load empty pallets and salvage into out-bound trucks	.43	2.08	1.03	4.96	.43	2.08	.67	3.20
Total (elemental time and cost)	2.30	11.04	4.55	21.84	1.53	7.36	2.39	11.44
15-percent personal and fatigue	.35	1.66	.68	3.28	.23	1.10	.36	1.72
Total (standard time and cost)	2.65	12.70	5.23	25.12	1.76	8.46	2.75	13.16
Productivity in cases unloaded per man-hour ²	377		191		566		366	

¹Based on an average driver wage rate of \$4.80 per hour or \$0.08 per minute.

²Calculated by dividing 1,000 cases by total man-hours.

hydraulic-lift platform. The standard time required for unloading pallets over a dock was 159 man-minutes per 1,000-cases average order, for a productivity rate of 377 cases per man-hour (table 5). Cost per 1,000 cases was \$12.70, compared with \$25.12 for the hydraulic-lift receiving platform. One of the problems of pallet receiving, especially with the lift platform and the "last-stop" stores, is the need to maneuver both loaded and empty pallets when unloading produce or when loading salvage. This problem is not as critical when the dock has pallets that can be moved aside during unloading.

Another pallet-unloading method has merit under certain conditions. This is the walkie-stacker forklift which, while operating on the ground level, takes the loaded pallet from the rear of the trailer and lowers it to the ground or possibly to a partial dock. This system requires a two-man crew: one to move the loaded pallet to the rear of the trailer with a pallet jack and one to operate the walkie-stacker. If the terrain is such that the walkie-stacker cannot be brought into the store to move the loaded pallet to storage, then a third crew member is required. In two stores where the walkie-stacker was used, and under different conditions, the average production and cost figures were identical with those when the lift platform was used.

Unloading Hand-Stacked Produce

The greatest variety of unloading methods was observed when the orders were shipped hand stacked in the trailer or on pallets and when no equipment was at the store to remove the pallet. The basic unloading devices were: (1) Hand carrying, (2) two-wheel handtrucks, (3) gravity-type conveyors (fig. 9),

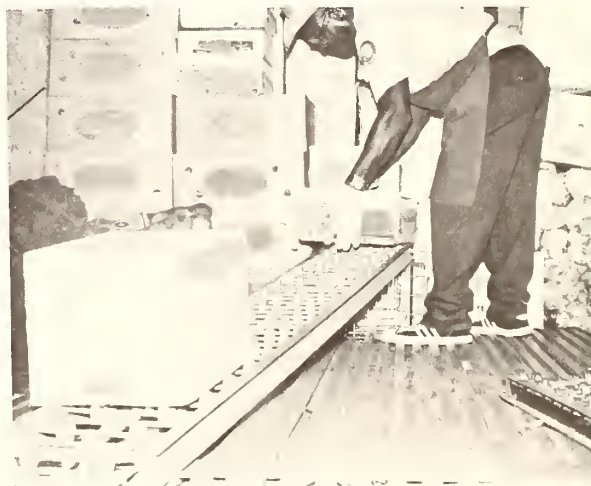


Figure 9.—Unloading produce by hand using a roller conveyor.

and (4) semilive skids.⁵ Within each unloading category, variations occurred as the driver adjusted to the receiving conditions at the store.

The most productive method of unloading by hand was the driver using a conveyor and acting alone. The driver would either carry the case to the conveyor in the trailer or else extend the conveyor to the product. When he had loaded the conveyor, the driver walked to the store backroom, removed the cases from the conveyor, and placed them on the floor inside the door. The conveyor was effective in the test stores because of the short distance from the trailer door to the storage area, and because the orders averaged 75 cases. The conveyor has limitations when: (1) Distance to storage increases, (2) the produce must be placed in a designated storage area, or (3) crew delays occur when a second person is needed. In other methods of receiving from a hand-stacked trailer, the two-wheel handtruck was an effective device for moving cases to the rear of the trailer. The semilive skid method of receiving had a low productivity because: (1) The driver carried cases to the rear door of the trailer, and (2) the driver segregated the produce on several skids.

The standard time to receive produce with conveyors was 73 man-minutes per average 200-case order, for a productivity rate of 164 cases per man-hour and at a cost of \$29.20 per 1,000 cases (table 6). The firms that deliver hand-stacked loads must cope with a variety of unloading methods, depending on the store. Therefore, the average of the four basic methods studied is probably the more accurate figure. The average cost per 1,000 cases was \$37.80,

⁵The semilive skid is a platform (30- and 60-inches in this study) with two rear wheels and a pin in the front that was used to engage and lift the front with a wheeled jack.

and the produce was unloaded at the average rate of 130 cases per man-hour.

Unloading With Mobile Carts

The cart method was developed as part of a unified handling system where the case is not touched between selection at the warehouse and storage in the store (fig. 10). In this study, the carts were unloaded either across a truck bed-level dock or down to the ground using an electrically operated elevator incorporated in the rear section of the trailer.



Figure 10. — Unloading produce with mobile carts on a hydraulic tailgate.

Whether unloading across a dock or down to the ground, one should make certain that the trailer parking area is level to avoid the danger of bruising the loaded produce. If traveling uphill, the carts were hard to push; if going downhill, they were hard to control, and drivers were observed to slip and fall. If

Table 6.—Labor productivity and cost per 1,000 cases for unloading produce shipped hand stacked in the trailer at the retail store

Method	Labor requirements		Productivity in cases per man-hour ¹	Cost per 1,000 cases ²
	200-case order	1,000-case order		
	Man-hours	Man-hours	Number	Dollars
Hand carrying into store	1.73	8.67	115	41.60
Two-wheel handtruck	1.58	7.92	126	38.00
Gravity conveyor	1.22	6.08	164	29.20
Semilive skid	1.77	8.83	113	42.40
Average	1.58	7.88	130	37.80

¹Calculated by dividing 1,000 cases by total man-hours.

²Based on an average wage rate of \$4.80 for drivers.

parked on a slide slope, the carts gravitated toward the side of the trailer. Therefore, a level area should be paved where the trailers park is desirable.

The standard time for unloading carts with produce across the dock was 106 minutes per 1,000 cases (table 5). At a rate of 566 cases per hour and a cost of \$8.46 per 1,000 cases, this was the most productive unloading system studied. A store that receives 1,000 cases of produce per week will save \$196 in labor per year by receiving via a dock, compared with the trailer lift.⁶ Besides the labor saving, the need for the trailer lift is eliminated, and equipment and receiving personnel are tied up for a shorter period.

Unloading Systems Compared

To make the systems comparable, all receiving studies were adjusted to an average of 200 cases per order. The least expensive unloading method was with mobile carts over a truck bed-level dock. Productivity was 566 cases per man-hour, compared with 377 cases per man-hour for the next most efficient method—pallets over a dock (table 5). Half of the cart-and-pallet stores were assumed to have docks and the other half to use some type of lift.

The average time (for dock and lift platform receiving) to unload the carts was 135 minutes per 1,000 cases, compared with 236 minutes for pallets (table 7). Productivity was 444 cases per man-hour for carts and 254 cases per man-hour for pallets. The pallet system requires more labor because of:

⁶Calculated as follows (table 5): \$13.16 - \$8.46 = \$4.70 per 1,000 cases x 41,600 cases per year = \$196.

(1) Engagement and disengagement of the pallet jack, (2) maneuvering in the trailer to get around empty pallets and salvage containers, and (3) greater mobility of the carts. A problem with cart receiving in some stores was the size and shape of the produce coolers, which were not designed to handle the carts.

The only hand-stack unloading method that compares with mobile carts or pallets is conveyor receiving. This system is limited in its lack of flexibility in moving produce to the assigned storage area and in its need for a helper or more elaborate conveyor equipment when the storage is farther from the trailer.

Table 7.—Labor productivity and cost per 1,000 cases for unloading produce shipped on pallets, by hand stacking, and on carts

Method	Time	Productivity in cases per man-hour	Cost
	<i>Man-hours</i>	<i>Number</i>	<i>Dollars</i>
Pallet ²	3.93	254	18.88
Hand stack ³	7.87	130	37.80
Cart ⁴	2.25	444	10.80

¹Based on an average wage rate of \$4.80 per hour.

²Average of dock and lift-platform unloading—least costly system was dock unloading at \$12.70 per 1,000 cases.

³Average of four methods used—least costly method was gravity conveyor receiving at \$29.20 per 1,000 cases.

⁴Average of dock and trailer-elevator unloading—least costly system was dock unloading at \$8.46 per 1,000 cases.

PRODUCE DELIVERY COSTS

Many factors affect delivery costs, but many are either not related to the delivery platform or simply cannot be controlled. Factors that are influenced by the delivery system are: (1) The driver's wages during transit and unloading; (2) the fixed costs of delivery equipment during loading, transit, and unloading (depreciation, interest, insurance, and taxes); (3) the potential revenue from backhauling freight to the warehouse; and (4) the average loaded capacity of the trailer for each delivery system. Not included in the comparison of the three delivery systems are over-time, equipment—breakdown time, or damage incurred during the delivery cycle. Each system has a

potential for damage, but it occurs more as a result of human error than as a result of the method of shipping. For example, if the load is not leveled or secured after each stop, the distinct possibility arises of cases falling during transit or, if fragile items are not placed at the top of the load, of damage resulting.

The cost of the driver's time was determined by averaging the hourly rate in effect at the cooperating firms. This rate was \$4.80 per hour, and it was applied to the three systems. Driver cost was charged for travel time and unloading time at the retail store. The fixed costs of delivery equipment included depreciation, maintenance, and interest on tractors and

refrigerated trailers (reefers).⁷ Half of the trailers that used carts were assumed to be equipped with elevators. The fixed costs for delivery equipment included the time for loading, traveling, and unloading. For a tractor and refrigerated trailer, the fixed cost for delivery equipment was \$2.35 per hour (table 8). Backhaul revenue was allocated to the hand-stack and pallet-delivery systems but not to the cart system.

The carts used by the cooperating firm (and by most firms that ship by cart) were rigidly constructed. If collapsible carts are used, 75 percent of the trailer's capacity can be used for backhaul. A considerable part of the potential backhaul revenue with collapsible carts is offset by: (1) Added cost of the carts, (2) loss of 25 percent of trailer capacity, and (3) the labor to erect and collapse the carts. The number of cases per loaded 40-foot trailer has a measurable effect on all the delivery cost factors. The larger the load, the fewer trips required to ship 1,000 cases. The number of trips influenced all of the delivery cost factors.

To establish comparability between the delivery systems, an average round trip had to be determined. Round trips ranged from 15 to 254 miles in the

studies. An average round trip of 80 miles was used for all delivery systems, and the assumed travel time was 2.67 hours, based on 30 miles per hour. Fleet costs, other than drivers' wages and fixed cost of equipment, were averaged from data supplied by the cooperating firms and were assumed to be equal for all systems of delivery for the 80-mile round trip.

In comparing delivery systems, the driver's time and cost are based on the time and miles required to deliver 1,000 cases and will vary by trailer capacity. The fixed cost for delivery was based on the equipment used and the hours to load, travel, and unload by each method of shipment. The other fleet operation costs were averaged for the firms studied and adjusted for each system by the number of miles required to ship 1,000 cases.

Pallet Delivery

The records from the cooperating firms that shipped on pallets showed that the average loaded 40-foot trailer held 787 cases. Although many firms used hydraulic-trailer lifts for unloading pallets, the firms studied used a lift platform located near the receiving door. The cost of this platform was charged to dock ownership. Unloading time was a factor in delivery costs because equipment was being tied up. One-half of the stores that shipped by pallet were assumed to have docks, while the remaining half were assumed to unload by lift platforms. The total delivery cost of

⁷Fleet managers may want to include the cost of insurance, licenses, and taxes as part of the fixed operating costs. They were not included in the delivery cost comparison because the method of reporting was not consistent for the firms.

Table 8.—Fixed costs per hour for delivery equipment

Equipment	Purchase cost ¹	Salvage value	Average life in years ¹	Annual depreciation cost ²	Annual interest cost ³	Total annual cost	Annual time in use ⁴	Fixed costs per hour ⁴
	Dollars	Dollars	Number	Dollars	Dollars	Dollars	Hours	Dollars
Tractor	24,750	⁵ 3,700	6	3,510	850	4,360	3,120	1.40
Reefer ⁶	13,750	⁷ 800	8	1,620	440	2,060	2,704	.76
Reefer with elevator	17,250	⁸ 1,000	8	2,030	550	2,580	2,704	.95
Tractor plus reefer	--	--	--	--	--	--	--	2.16
Tractor plus reefer with elevator	--	--	--	--	--	--	--	2.35

¹Averaged from data supplied by cooperating firms.

²Straight line depreciation (purchase cost - salvage value ÷ average life).

³Calculated as follows: purchase cost + salvage value ÷ 2 = average investment. Average investment x percent (the prevailing interest rate at time of study) = annual interest cost.

⁴Annual costs - annual time in use.

⁵Assumed to be approximately 15 percent of purchase cost, based on a survey conducted by the National American Wholesale Grocers Assoc. The assumption was confirmed by local dealers.

⁶Reefer is a refrigerated trailer.

⁷Value quoted by fleet manager.

⁸Estimated, equipment not on used market.

pallet shipment was \$49.43 per 1,000 cases. The revenue from backhaul of freight was \$10.37 per 1,000 cases (table 9).

Hand-Stack Delivery

The largest loads, an average of 830 cases per 40-foot trailer, occurred when the produce was stacked by hand. The method of unloading affects delivery cost, and various methods were studied. Since it was normal for a firm to have various receiving methods, the average of several methods was used. The total delivery cost for hand-stacked shipments was \$59.89 per 1,000 cases. The revenue from the backhaul of freight (\$9.76 per 1,000 cases) reduced the average delivery cost to \$50.13 per 1,000 cases (table 9). The delivery cost was high for hand-stacked shipments because more time was required to load and unload the trailer manually.

Mobile Cart Delivery

A review of shipping records showed the average

full load for a 40-foot trailer to be 23 carts with 704 cases. An additional cart can be loaded, but fleet managers like to avoid having three loaded carts on the elevator. The cost of delivery by carts was \$51.48 per 1,000 cases (table 9). Backhaul revenue was not credited to cart delivery because rigid carts were used, and all available space was needed for returning empty carts.

Delivery Costs Compared for Pallets, Hand Stacking, and Carts

The pallet system had both the lowest gross and the lowest net delivery cost. The lower cost of the pallet delivery was due to the unitized loading and unloading, the capacity of the loaded trailer, and the revenue from backhaul. The hand-stacking system, which had the highest trailer capacity and backhaul revenue as well, was a high-cost delivery system because of the time required to load and unload the trailers

Table 9.—Delivery costs per 1,000 cases for an 80-mile round trip for alternate methods of shipping produce

Item of cost	System					
	Pallet		Hand stacking		Mobile cart	
	Hours	Dollars	Hours	Dollars	Hours	Dollars
Driver's time ¹	3.39	16.27	3.20	15.36	3.79	18.19
Fixed costs for delivery equipment ²	37.94	17.15	13.64	29.46	6.81	15.39
Other fleet operations:						
Costs @ \$0.157 per mile ⁶	--	16.01	--	15.07	--	17.90
Gross cost	--	49.43	--	59.89	--	51.48
Backhaul revenue ⁷	--	10.37	--	9.76	--	--
Net delivery cost	--	39.06	--	50.13	--	51.48

¹Calculated as follows: Hand stacking—830-case load capacity and 1.20 loads per 1,000 cases; 2.67 hours travel (80 mi.÷30 mi. x 1.20 = 3.20 hours travel time x \$4.80 per hour; pallet—787-case load capacity and 1.27 loads per 1,000 cases; 2.67 x 1.27 = 3.39 travel hours x \$4.80 per hour; cart—704-case load capacity and 1.42 trips per 1,000 cases; 2.67 x 1.42 = 3.79 travel hours x \$4.80. Driver time during unloading charged to unloading.

²Fixed cost per fleet operating hours reported in table 13 tractor and reefer @ \$2.16 per hour and tractor and reefer with elevator @ \$2.35 per hour; assume for cart deliveries that half of the reefers have elevators.

³Calculated as follows: loading—0.62 hour, travel—3.39 hours, unloading—3.93 hours = 7.94 hours @ \$2.16.

⁴Calculated as follows: loading—2.58 hours, travel—3.20 hours, unloading—7.86 hours = 13.64 hours @ \$2.16.

⁵Calculated as follows: loading—1.05 hours, travel—3.79 hours, unloading—1.97 hours = 6.81 hours @ \$2.26.

⁶Miles per 1,000 cases calculated as follows: 80 miles round trip per load x number of trips per 1,000 cases = miles per 1,000 cases; hand stacking—96 miles, pallet—102 miles, cart—114 miles.

⁷Based on an average of \$0.1017 per mile in cooperating hand-stacking and pallet-delivery firms. Hand stacking—96 miles per 1,000 cases x \$0.1017 = \$9.76, pallet—102 miles per 1,000 cases x \$0.1017 = \$10.37

manually. The cart system had the lowest trailer capacity and, in this study, did not have backhaul revenue.

The reason for the difference in backhaul revenue

between the pallet and the hand-stacking system (\$10.37 vs. \$9.76) is that the hand-stacking system has a large trailer capacity and, therefore, a lower mileage per 1,000 cases (table 9) footnote 7.

COSTS FOR EQUIPMENT, DOCK OWNERSHIP, AND STRUCTURAL ALTERATIONS

The equipment and facilities required at the warehouse and retail stores for the total produce distribution system are, to a large extent, controlled by the handling system employed by the firm. The differences in equipment at the warehouse are largely limited to selection and loading; for example, the structure and storage racks can be used for any system. The only equipment essential for a hand-stacking operation is a four-wheel selector truck. Firm B, which had the long-selection line and which hand stacked produce into the trailers, used both tuggers with four-wheel selector trucks and electric

pallet jacks to select produce. Equipment used for selection with pallets were the electric pallet jack and warehouse pallets. The cart system used the four-wheel carts and electric tuggers.

The equipment at the stores varied according to the unloading method: two-wheel trucks, conveyors, and semilive skids for hand stacking; docks, lift platforms, and walkie-stackers for pallets; and docks and trailer elevators for carts. In the cost comparison, the following assumptions were made: (1) Selection for hand stacking was equal on four-wheel selector trucks pulled by tuggers and on pallets moved by

*Table 10.—Cost of equipment, dock ownership, and structural alterations
for the pallet, hand-stacking, and cart systems of handling produce
from warehouse selection to storage in the store*

Item of cost	System		
	Pallet	Hand stacking	Mobile cart
	Dollars	Dollars	Dollars
Warehouse equipment:			
4-wheel selector trucks ¹	--	0.12	--
GMAC pallets, 48 x 40	² 1.01	³ 1.50	--
⁴ Electric pallet jack ⁴	2.84	--	--
Electric tuggers ⁵	--	3.61	3.61
Mobile carts ⁶	--	--	12.21
Store:			
Door and dock modification ⁷	.77	--	.77
Hydraulic lift platform ⁸	1.80	--	--
Miscellaneous receiving equipment ⁹	1.05	.96	--
Total	7.47	5.19	16.59

¹Based on annual costs (depreciation, maintenance, and interest) amounting to \$178 ÷ 1,482,000 cases per year.

²Based on 600 pallets @ \$5.00 with 2-year usage and with 1,482,000 cases per year.

³Pallets used only in selection, so require only ½ as many as with pallet shipment.

⁴Based on annual costs (depreciation, maintenance, and interest) amount to \$4,202 ÷ 1,482,000 cases per year.

⁵Based on annual costs (depreciation, maintenance, and interest) amounting to \$5,347 ÷ 1,482,000 cases per year.

⁶Based on annual costs (depreciation, maintenance, and interest for 15 carts per store) amounting to \$508 ÷ 41,600 cases per year.

⁷Amortized cost of dock installation, dock alteration, etc.

⁸Based on annual costs (depreciation, maintenance, and interest) amounting to \$225 per year ÷ 41,600 cases per year. Note, only 1/3 of cost charged to produce.

⁹Includes cost of pallet jacks, conveyors, 2-wheel trucks, semilive skids, etc.

electric pallet jacks; (2) the cost of the trailer elevator was included in delivery costs; (3) half of the cart-and-pallet stores had docks and the rest used lift platforms (pallets) and trailer elevators (carts); and (4) the costs of installing a dock or modifying doors were supplied by the cooperating firms.

Table 10 shows that the hand-stacking system has

the lowest equipment costs, and carts, the highest. The high cost of ownership and equipment for carts is due primarily to the cost of the carts—which was \$12.21 per 1,000 cases, compared with \$1.01 for warehouse pallets. The total cost of equipment, dock ownership, and structural alterations per 1,000 cases was \$5.19 for hand stacking, \$7.47 for pallets, and \$16.59 for carts.

TOTAL HANDLING COSTS

The total costs of handling produce from warehouse storage to the produce backroom of the retail store are shown in table 11. The results of the comparison show the pallet system, at \$103.75 per 1,000 cases, to be the least expensive total-handling system. Mobile carts were the second least expensive system at \$113.40 per 1,000 cases delivered to the warehouse. Shipping produce hand stacked in the trailer was the most expensive system at \$140.71 per 1,000 cases.

The availability of backhaul is a factor in the cost of the handling systems. Firms that shipped on pallets and that hand stacked had a revenue from backhaul—\$10.37 for pallets and \$9.76 for hand-stacked loads per 1,000 cases. Credits for backhaul revenue lowered the cost per 1,000 cases to \$93.38 for pallets and \$130.95 for hand stacking.

The cart firm in the study used rigid carts; hence, all available space in the trailer was used for returning empty carts. Collapsible carts will make 75 percent of the trailer space available for backhaul, but adjustments should be made for the higher cost of the labor to erect and collapse the carts. Carts without a shelf would increase the capacity of the trailer for each selection route and would slightly lower total system cost. Neither cart nor pallet are typically used to move produce from the backroom to the sales area, so there is no opportunity to realize savings from further extension of unitized handling with the two platforms.

If the produce-handling systems are analyzed on

Table 11.—Total warehouse and retail store costs per 1,000 cases for handling produce from warehouse to the retail produce storage area with pallet, hand-stacking and cart delivery systems

Item	System		
	Pallet	Hand stacking	Cart
	<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>
Warehouse labor:			
Selecting	21.90	22.88	26.48
Restocking	3.30	3.30	3.30
Loading	2.77	11.65	4.75
Retail store receiving	18.88	37.80	10.80
Delivery	49.43	59.89	51.48
Equipment, dock ownership, and structural alterations.	7.47	5.19	16.59
Gross cost	103.75	140.71	113.40
Backhaul revenue	10.37	9.76	--
Net cost	93.38	130.95	113.40

an annual basis (table 12), possible savings ranged from a minimum of \$7,900 per year to a maximum of \$149,000 per year. Table 12 also shows how to convert your sales to tons shipped and cases shipped per year, and how to find your annual cost based on either the pallet, hand-stacking, or cart system.

MULTISTORE PRODUCE DELIVERIES VS. COMBINING PRODUCE WITH OTHER COMMODITIES

During the study of produce-handling systems, multistop produce vs. one-stop deliveries was discussed with the transportation managers and the produce executives of the cooperating firms. The

goals of low-cost distribution and the maintenance of quality were common, but there were different pressures on the executives. To have frequent deliveries and low-cost distribution, shipping

Table 12.—Annual cost and savings of the 3 produce handling systems

Amount of sales (mil. dol)	Sales in quantity of product shipped		Cost per year ³			Savings per year		
	Per \$300 per ton ¹	Per 42 lb cases ²	Pallet at \$93.38 per 1,000 cases	Hand stack at \$130.95 per 1,000 cases	Cart at \$113.40 per 1,000 cases	Pallet vs.		Cart vs. hand stack
						Hand stack	Cart	
	<i>Ton</i>	<i>Thous. cases</i>	<i>Thous. dol.</i>	<i>Thous. dol.</i>	<i>Thous. dol.</i>	<i>Thous. dol.</i>	<i>Thous. dol.</i>	<i>Thous. dol.</i>
2.5	8.333	396.8	37.1	52.0	45.0	14.9	7.9	7.0
5.0	16.667	793.7	74.1	103.9	90.0	29.8	15.9	13.9
7.5	25.000	1,190.5	111.2	155.9	135.0	44.7	23.8	20.9
10.0	33.333	1,587.3	148.2	207.9	180.0	59.7	31.8	27.9
12.5	41.667	1,984.1	185.3	259.8	225.0	74.5	39.7	34.8
15.0	50.000	2,381.0	222.3	311.8	270.0	89.5	47.7	41.8
17.5	58.333	2,777.8	259.4	363.8	315.0	104.4	55.6	48.8
20.0	66.667	3,174.6	296.4	415.7	360.0	119.3	63.6	55.7
22.5	75.000	3,571.4	333.5	467.7	405.0	134.2	71.5	62.7
25.0	83.333	3,968.2	370.6	519.6	450.0	149.0	79.4	69.6

¹Annual tons equal annual sales ÷ 300.

²Annual cases equal annual tons x 2,000 lb. ÷ 42 lb.

³Annual cost per year equals annual cases of system per 1,000 cases (pallet \$93.38; hand stacking \$130.95; and cart, \$113.40)

produce with the grocery order and frequently without adequate temperature control was often necessary.

The director of transportation was faced with a more complicated fleet-scheduling problem when he combined loads. Scheduling, selection, and loading at the warehouse to build combination loads is difficult, and it is equally difficult achieving full loads when shipping straight grocery loads to a store and a produce shuttle to several stores. Rarely does a store order an equal number of full loads per week, and produce orders are typically heavy toward the end of the week. How does one determine when to combine loads?

Sometimes it is relatively easy to resolve the problem. City and suburban stores should be served with full grocery loads and multistore produce deliveries. The isolated store remote from the warehouse should receive a combination load to provide the store with adequate perishable deliveries economically. The problem is to keep trailers full and to best serve the out-of-town stores that *can* be grouped so the mileage for the round trip to the stores on the route is less than the sum of the round trip miles to the individual stores. Some factors that influence whether to use combined loads or straight grocery loads with produce shuttle runs are listed below:

1. The number of produce and grocery deliveries per store per week. Any increase in the number of produce deliveries or any decrease in the number of grocery deliveries per week will encourage the use of produce shuttle and straight grocery loads.
2. The cost of delivery equipment. The more trailers that leave the warehouse with produce, the greater the need for refrigerated trailers plus additional fuel and maintenance.
3. The question of whether other commodities—meat, bakery goods, dairy goods, and frozen food—are also on the combination load.
4. The flexibility in trailer size to adjust to different load requirements.
5. The availability of backhaul freight. Freight cannot be loaded until the trailer is empty, and the last store of a shuttle run may not be near the loading point of the freight.
6. The question: Is grocery space allocated in the stores? If space is so allocated, the grocery deliveries should be scheduled with consideration for the daily distribution of grocery sales.

7. The time of the selection shifts at the warehouse for the different commodities and the physical problems of carrying the combination loads.
8. The availability of store personnel to receive a combination load, and the time that the load is scheduled to arrive at the store.
9. The size of the store. Every store should receive a minimum of three produce deliveries per week; yet, the small stores cannot economically receive three full combination loads every week.
10. The grocery warehouse productivity. When produce and other perishable commodities are loaded with grocery items, the number of grocery cases per load is reduced. This results in more grocery orders to process, with reduced selector productivity and increased loading time as the various commodities are combined and loaded.
11. The need for fixed delivery schedules at the store. Ideally, the delivery schedule should be subject to daily adjustment. This precise scheduling is not possible because of the necessity for the stores to have a fixed receiving schedule in order to control hours and product availability.

To compare the costs of combined loads and shuttle produce runs, three types of delivery routes in one firm were studied. This firm shipped dairy goods on some of the produce loads, so in one sense they had moved one step toward combined loads. All except one of the cooperating firms shipped dairy goods with produce, and the studies were adjusted to remove the effect of the dairy items. Controlling all factors that affect delivery costs for combined and shuttle runs is impossible, so certain assumptions were made: (1) Each store would receive two grocery and three produce orders per week, (2) the average cost of transportation was \$0.40 per mile, (3) all

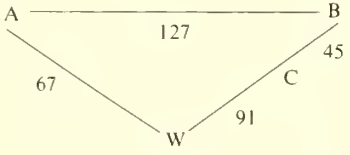
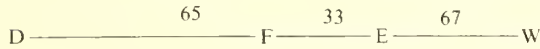
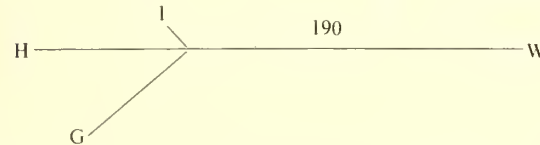
trailers left the warehouse reasonably full, and (4) the warehouse had the capability of combining grocery and produce orders.

The cost of supplying three stores on a triangular (or circular) route and on a straight line route was less with one stop combination loads (table 13). The savings per week were \$138 (16 percent) on the triangular route and \$130 (14 percent) on the straight line route. The cost of supplying three stores in a satellite city was the same for both types of delivery. A study of a second straight line route with four stores, but where two stores received two grocery loads per week, and two stores received 1½ grocery loads per week, showed the shuttle-straight line delivery system to be the least costly. This study assumed that the two half loads were combined on one trailer. As long as one of the criteria is reasonably full loads leaving the warehouse, the controlling factor is distance traveled by either system. When the ratio of produce to grocery deliveries per store increases, the shuttle-straight line delivery system seems more advantageous.

The analysis did not consider differences in volume requirements among the stores on a given produce shuttle route. A large store that requires four full grocery loads per week presents a different problem than the small store that needs only one grocery load per week. The small store creates a problem because it requires as many produce deliveries as the large stores in order to have fresh produce, although the larger stores may require more deliveries to handle the produce volume.

The need to increase productivity in the retail food industry dictates that each firm search for the least expensive delivery system. Several of the keys to the development of an optimum delivery system are available. In several firms, case cubes are listed on the picking lists by item and total. This helps the dispatcher to utilize all the cubic space in the trailer. Compartmentized trailers permit the shipment of combination loads with proper refrigeration. Vehicle scheduling programs (VSP) use computers to develop and to maintain a delivery schedule.

Table 13.—Delivery cost for combination loads and produce multistore runs with full grocery loads for 3 types of delivery routes¹

One-stop combination loads					Multistore produce and full grocery loads				
Store code	Miles per trip	Orders per week	Cost per load at \$0.40 per mile	Total miles per week	Store code	Miles per trip	Orders per week	Cost per load at \$0.40 per mile	Total miles per week
Letter	Number	Number	Dollars	Number	Letter	Number	Number	Dollars	Number
Triangular route					Full grocery loads:				
A	134	3	161	402	A	134	2	107	268
B	272	3	326	816	B	272	2	218	544
C	182	3	218	546	C	182	2	146	364
					Produce				
					310 3 372 930				
Total		9	705	1,764	Total		9	843	2,106
Straight line route									
					Full grocery loads:				
D	330	3	396	990	D	330	2	264	660
E	134	3	161	402	E	134	2	107	268
F	200	3	240	600	F	200	2	160	400
					Produce				
					330 3 396 990				
Total		9	797	1,992	Total		9	927	2,318
Cluster of stores in satellite city									
					Full grocery loads:				
G	385	3	462	1,155	G	385	2	308	770
H	385	3	462	1,155	H	385	2	308	770
I	385	3	462	1,155	I	385	2	308	770
					Produce				
					385 3 462 1,155				
Total		9	1,386	3,465	Total		9	1,386	3,465

¹Diagrams illustrate visually the 3 types of delivery routes and their relationship to the originating warehouse.

RECOMMENDATIONS

This study has shown that the pallet system is the least expensive total system for each part of the distribution cycle except receiving at the store. The pallet system can be further improved if the following steps are taken:

1. Increase the number of items that are selected on full or partly full pallets. This could include watermelons and bagged potatoes in pallet containers, and items such as lettuce and bananas, where the average order often is a full pallet.
2. Have a separate picking list printout for pallet selection items and have the forklift operator select these items.
3. Use double-link (long-nose) pallet jacks that hold two 48- by 40-inch pallets to reduce the number of trips to the dock and return.
4. Organize the selection route so that items that are heavy and uniform will be located first in the route. This will result in a better pallet block.
5. Locate special shipping containers, such as those used for warehouse-packaged produce, in the same area to enable the selector to build a better load.
6. Tape the pallets that seem unstable to improve receiving at the store.
7. Build docks at the stores. This will reduce unloading costs by \$11.96 per 1,000 cases.

Each warehouse manager is encouraged to take the approach followed in this study to analyze his produce distribution costs. By substituting the labor and equipment costs for his firm, he will have a better picture of total costs and can determine his best total-produce distribution system.

APPENDIX

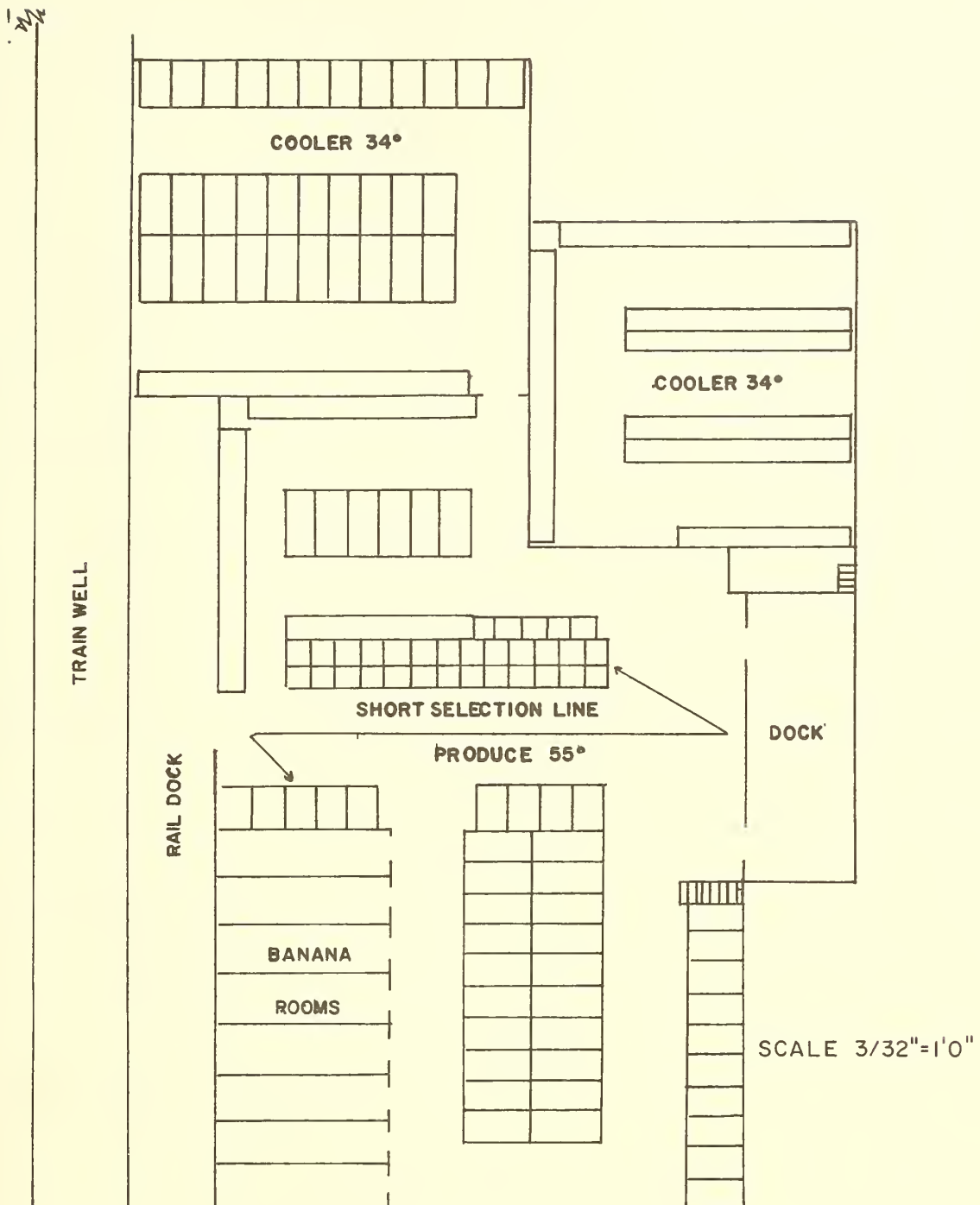


Figure 11.—Produce warehouse—firm A.

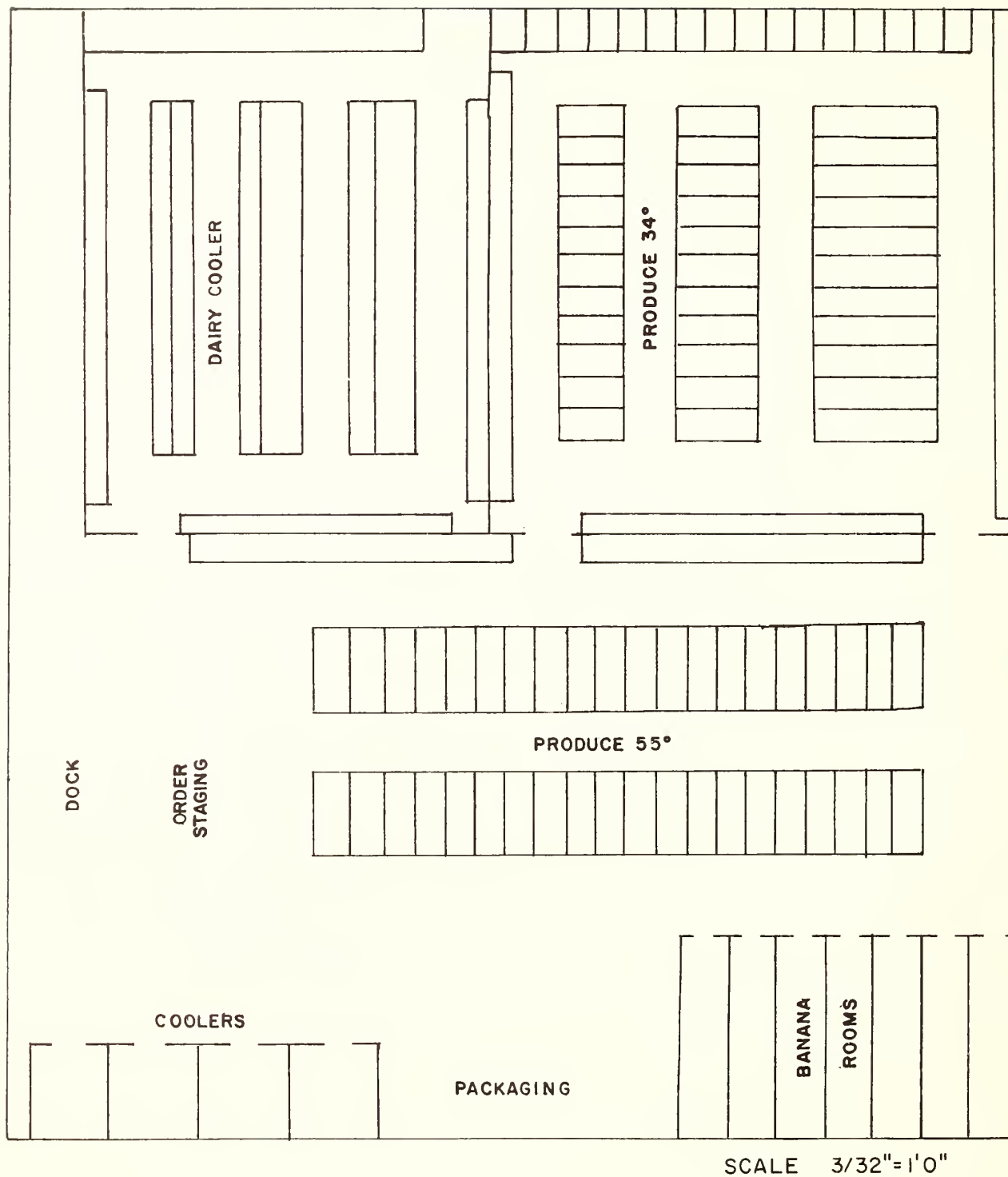


Figure 12. -Produce warehouse--firm B.

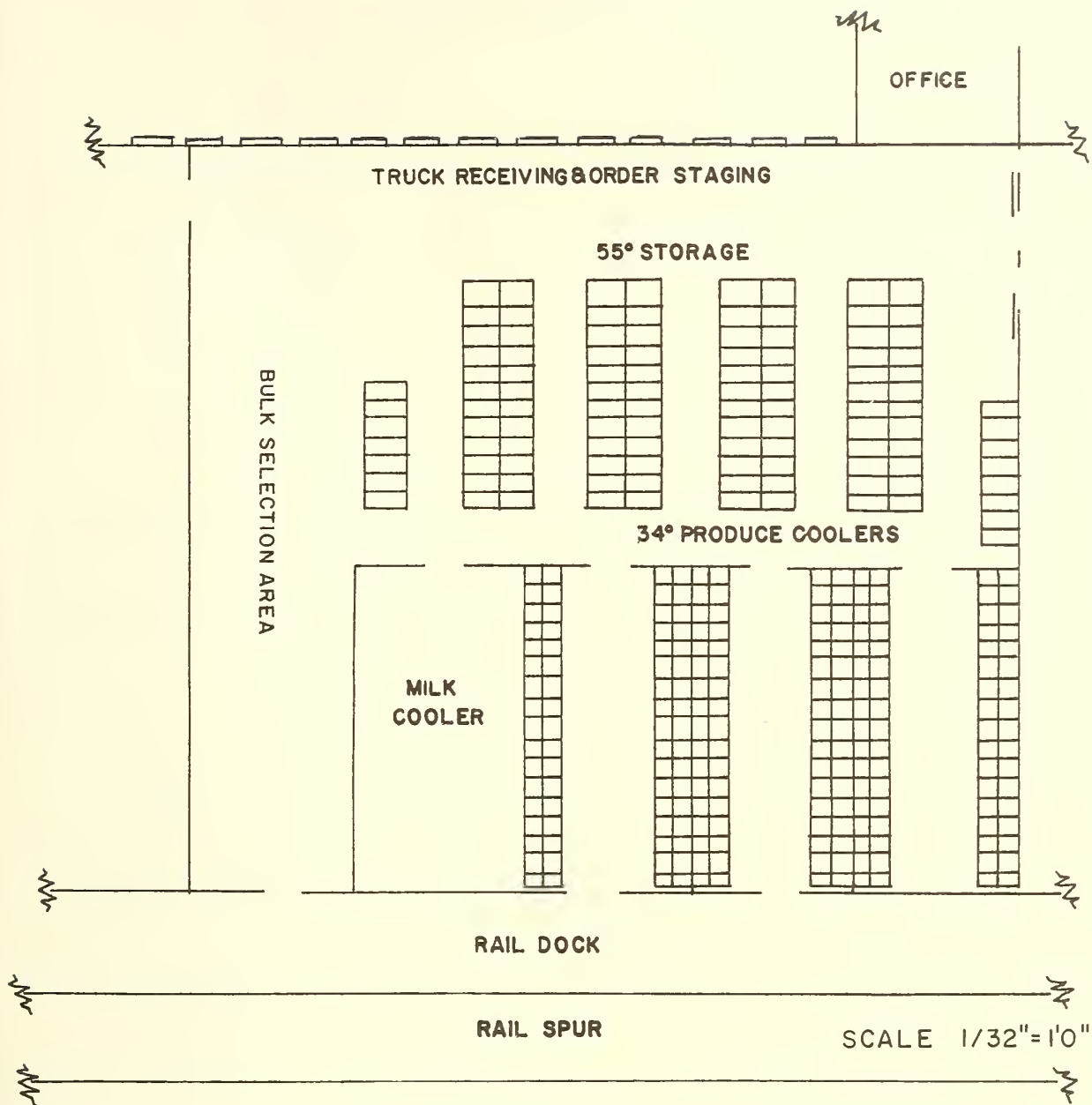


Figure 13.—Produce warehouse—firm D.

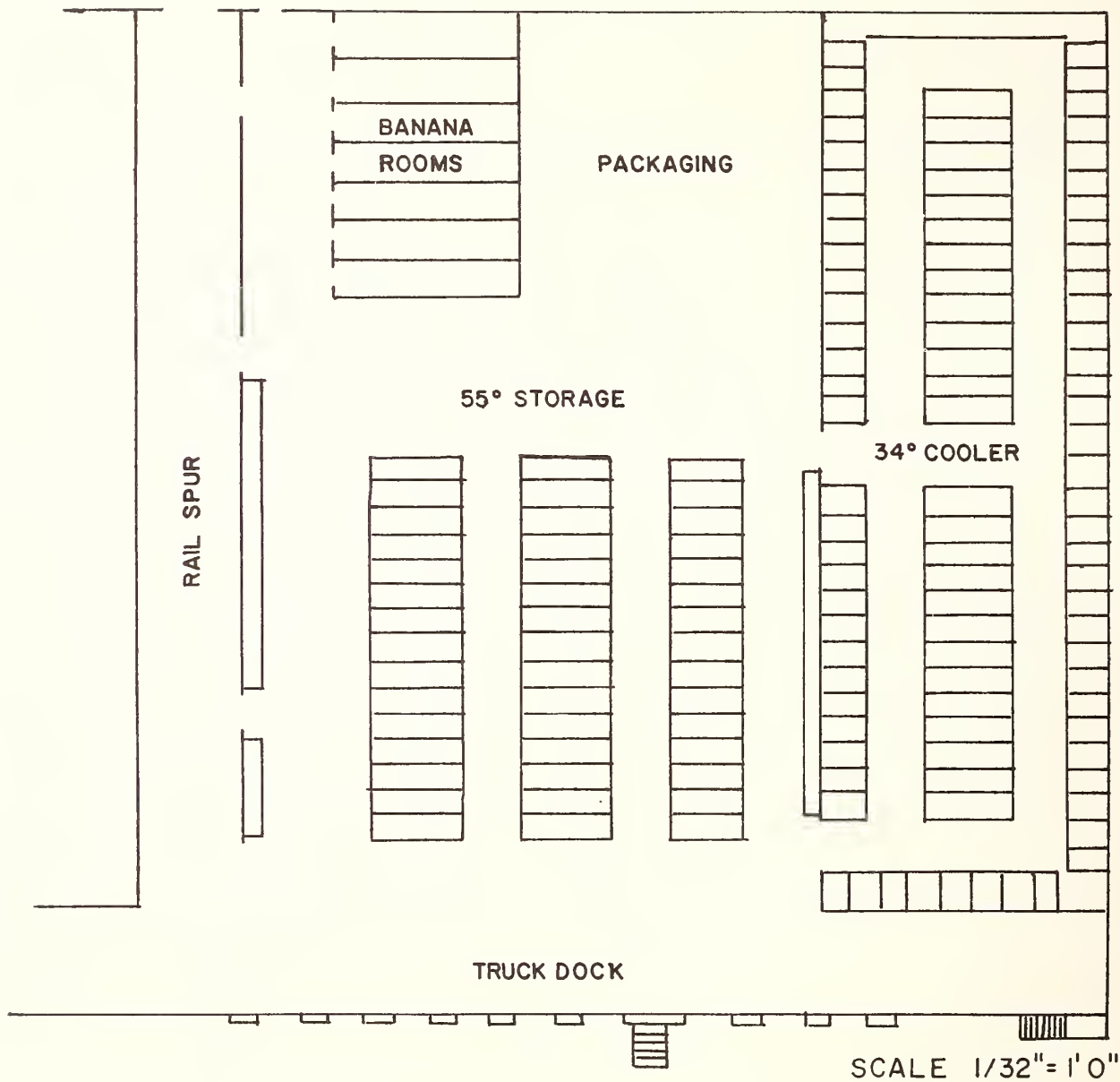


Figure 14.— Produce warehouse—firm G.